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WHAT PREDICTS THE TECHNICAL EFFICIENCY IN MALAYSIA'S FOOD PROCESSING INDUSTRY?

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ABSTRACT

The present study adopts data envelopment analysis (DEA) and Tobit regression to focus on the technical efficiency of small and medium enterprises (SMEs) and large-scale enterprises (LSEs) in Malaysia's food processing industry. The empirical results provide that the SMEs' technical efficiency score in constant return to scale (CRS) and variable return to scale (VRS) are 0.940 and 0.986, respectively, which indicates that SMEs can enhance the output level by 6 per cent for CRS and 1.4 per cent for VRS using a given level of inputs. Moreover, the technical efficiency levels of LSEs are 0.673 and 0.942 from CRS and VRS, respectively. The findings also suggest that training cost, research and development, and foreign direct investment positively affect technical efficiency. In contrast, information and technology, public infrastructure, and trade openness negatively affect the technical efficiency of SMEs. On the other hand, government infrastructure and trade openness positively connect with the technical efficiency of LSEs in Malaysia's food processing industry. Contradiction, research and development, and world oil prices negatively affect the technical efficiency in LSEs, indicating that the higher these variables, the higher the efficiency in LSEs.

Keywords: Technical efficiency, food processing industry (FPI), data envelopment analysis (DEA), small and medium enterprises (SMEs), large scale enterprises (LSEs)

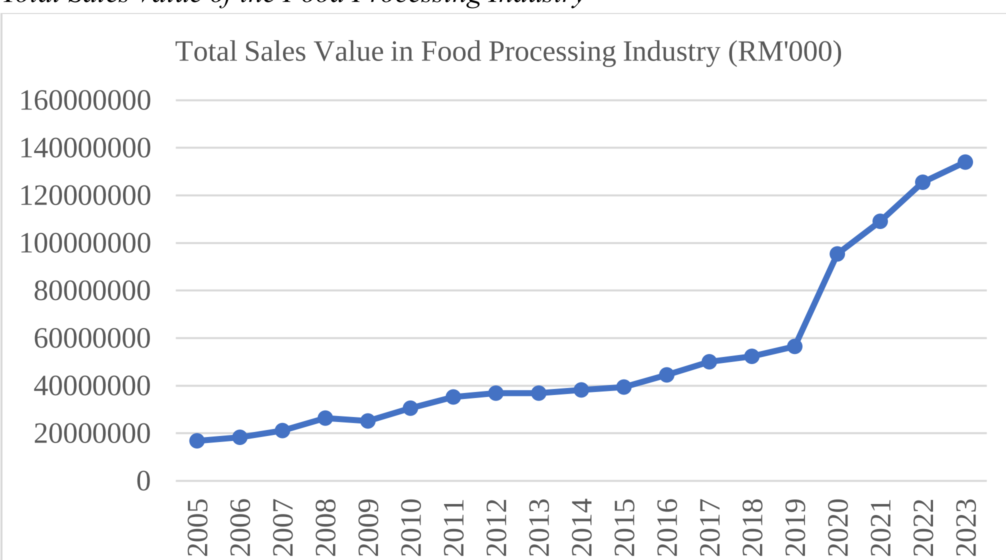
INTRODUCTION

The food processing industry (FPI) is closely tied to the agriculture and manufacturing industries, as the FPI includes converting raw materials from agriculture into food products or finished goods through manufacturing. Malaysia's FPI has undergone significant evolvement since it was encouraged by the industrialization policy in the 1960s and has continued to expand substantially. Under the 11th Malaysia Plan, efficiency and productivity are essential for stimulating economic growth, with industry and economic development driven by the efficient use of human capital and resources (Economic Planning Unit, 2016). The plan thus prioritizes productivity and efficiency to foster a more sustainable, comprehensive, and rapidly developing economy. The 12th Malaysia Plan has also highlighted inefficient resource management as a critical governmental concern. Industry performance is thus often assessed through efficiency metrics (Coelli et al., 2005).

As shown in Figure 1, the total sales value of Malaysia's FPI steadily rose from 2005 to 2023, underlining its growing role in supporting the national economy. Remarkably, sales surged during COVID-19 from RM 56.51 billion to RM 134 billion, more than doubling, reflecting the industry's importance in times of crisis. This growth has contributed significantly to the economy, adding value to primary products, creating jobs, and enhancing Malaysia's position as a processed food exporter. In 2022, Malaysia's processed food exports surpassed RM 28 billion, reflecting a 15.5% increase from the previous year (Bank Negara Malaysia, 2023). Additionally, the FPI ranked fourth in manufacturing investment, with a total investment of around RM8.5 billion (Malaysian Investment Development Authority, 2022).

Figure 1

Total Sales Value of the Food Processing Industry



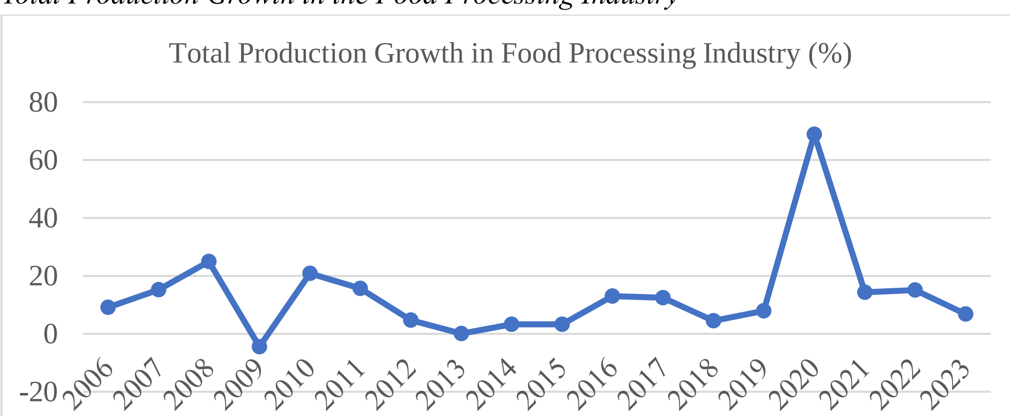
Despite these achievements, challenges have remained. A report from the Ministry of Economy highlights issues with supply chain management and low levels of automation, particularly among small and medium enterprises (SMEs) (Economic Planning Unit, 2017). Malaysia's FPI includes both SMEs and large-scale enterprises (LSEs). SMEs play an essential role in economic development, representing over 97 percent of total business establishments and 38.4 percent of GDP in 2022 (SME Corp. Malaysia, 2023). They also generated RM144.5 billion in exports in 2022, up from RM124.3 billion the previous year (SME Corp. Malaysia, 2024). SMEs dominate the FPI, accounting for over 80 per cent of businesses. However, LSEs also play a significant role by creating jobs and generating export revenue, especially in crucial areas like palm oil, cocoa, and livestock products (Flanders Investment and Trade Malaysia Office, 2020).

While the industry has shown growth in sales, production growth has been inconsistent, with periods of decline from 2006 to 2023 (Figure 2). Negative growth in 2009 and further decreases from 2010 to 2013, 2016 to 2018, and 2020 to 2023 suggest underlying inefficiencies. According to Coelli et al. (2005), the performance of an industry can be measured by its efficiency level, with higher efficiency values indicating better performance. Efficiency reflects an industry's ability to maximize output with available resources. Inefficiency, on the other hand, indicates suboptimal resource use, which can hinder production, productivity, and efficiency.

Given these challenges, assessing the efficiency of Malaysia's FPI is crucial, particularly in the post-COVID-19 context, in which economic resilience is vital. Unlike previous studies, which have focussed on efficiency in larger economies or the general manufacturing industry, this study addresses the specific efficiency challenges in Malaysia's FPI. The emphasis on SMEs reflects a research gap in the food processing industry and SME-oriented efficiency analysis. Although some studies have examined efficiency in Malaysia's FPI, they have yet to concurrently examine both LSEs and SMEs or the factors contributing to their inefficiency.

This study aims to evaluate the efficiency of SMEs and LSEs in Malaysia's FPI and investigate the factors that affect their inefficiency. By analyzing technical efficiency using data envelopment analysis (DEA), this study contributes to the literature through a dual focus on SMEs and LSEs, providing insights into efficiency determinants specific to Malaysia and addressing the gaps in existing research on Malaysia's FPI. The findings offer practical implications for improving efficiency within the FPI, especially for SMEs, and ultimately increase economic growth.

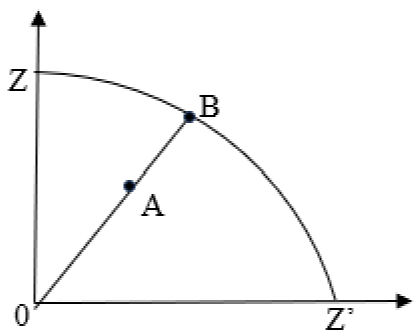
Figure 2
Total Production Growth in the Food Processing Industry



LITERATURE REVIEW

Technical efficiency refers to the relationship between resource inputs and outputs. It refers to the degree of effectiveness in utilizing a specific set of inputs to generate an output. Hence, efficiency is crucial for Malaysia's FPI, for which constraints like resource scarcity and high SME participation create unique efficiency challenges. A company is considered technically efficient when it achieves the highest possible output using the given inputs, including labor, capital, and technology. According to Coelli et al. (2005), the two core orientations in examining efficiency are input-oriented and output-oriented measures. This study applies the output-oriented measure and considers the output perspective given a fixed input. It measures how much the output of a Decision-Making Unit (DMU) can be maximized while keeping the input constant. Output-oriented efficiency is depicted in Figure 3, where the production possibility curve is denoted as ZZ'. Point A is located below the ZZ' curve, implying that the firm organizing at point A is not technically efficient. The gap between point A and point B indicates the extent of technical inefficiency, suggesting that a firm should escalate output production from point A to point B while maintaining the same input level. In the context of output-oriented efficiency, technical efficiency is considered to be the ratio of 0A to 0B and describes the potential output production increment from the initial point A to point B.

Figure 3
Output-Oriented Efficiency



Farrell (1957) introduced efficiency evaluation by employing multiple inputs and technical efficiency through the concept of the production frontier. Farrell's concept was further refined by Charnes et al. (1978), leading to the concepts of data envelopment analysis (DEA) and decision-making unit (DMU). This study has opted for DEA output-oriented efficiency, as DEA is a widely employed method for assessing efficiency and productivity across various industries. DEA's key advantages include distinguishing from traditional mathematical programming techniques, which often rely on assumptions about the production function, such as revenue maximization or cost minimization. Additionally, DEA does not require knowledge of the input and output prices when analyzing the technical efficiency. Instead, DEA builds up a non-parametric envelopment frontier or surface based on the points of data. This enables the determination of the efficiency frontier and relative efficiency of DMU within DEA. DEA method is commonly applied when assessing technical efficiency in the food processing (Ali et al., 2009; Arunkumar & Ramanan, 2017; Bhandari & Valiyattoor, 2016; Cechura & Kroupová, 2021; Eucabeth Majiwa, Boon L. Lee, Clevo Wilson, Hidemichi Fujii, 2018; Fragoso & Vieira, 2022; Hajihassaniasl, 2021; Le et al., 2021; Náglová & Pechrová, 2018; Pervan, 2021; Sulaiman & Ismail, 2021) and manufacturing industries (Al-Durgham et al., 2021; Charoenrat & Harvie, 2017; Im & Cho, 2021). Because SMEs dominate the FPI, technical efficiency analysis is essential in the context of Malaysia's FPI. This study uses DEA to capture efficiency levels within this unique economic structure to reach locally relevant insights.

This study draws upon several theoretical frameworks, including Neoclassical Growth Theory, which asserts that output growth is driven solely by increases in population (labour) and technological progress, with savings and investment having no impact on the long-term growth rate (Solow, 1956). Idrisov et al. (2015) expanded on the Solow model, suggesting that sustainable economic growth could align with population and labour productivity growth rates and rising global oil prices. A rise in oil prices represents increased wealth transfers from other countries, which generates additional investment and boosts capital accumulation in the domestic economy. Romer (1986) argued that productivity and efficiency can be enhanced through various strategies, including investment in research and development, support for education and training, and fostering innovation and entrepreneurship. They also posited that Foreign Direct Investment (FDI) promotes productivity and efficiency by enabling capital accumulation and facilitating technology transfer.

Moreover, the notion of stimulating economic growth through government infrastructure investment is based on Keynesian economic theory (Keynes, 1936). Keynesian economists contend that public infrastructure investments increase productivity and efficiency by reducing transportation and communication costs, improving market access and resource availability, and facilitating business operations. Furthermore, comparative advantage suggests that countries can benefit from international trade by specializing in the goods and services they can produce most efficiently and at the lowest opportunity cost relative to other nations. Trade openness often serves as an indicator of international trade, as higher trade openness suggests a country is producing goods with greater productivity and efficiency (Letiche, 1960).

The literature broadly consists of empirical studies of technical efficiency in the FPI. For example, Khan and Abdulla (2019) examined the technical efficiency of SME sugar mills in Maharashtra and Uttar Pradesh, and the findings indicated that the average technical efficiency levels of Maharashtra and Uttar Pradesh were 66 per cent and 64 per cent, respectively. Additionally, the authors argued that the sugar industry is capital-intensive and that information and technology negatively affected technical inefficiency, using the ratio of computer to fixed capital to elicit the role of information and technology service in the sugar mill of Maharashtra. In addition, Bhandari and Valiyattoor (2016) explored technical efficiency and the factors affecting technical efficiency in the Indian FPI from 2000 to 2015 through the DEA method. They found that the dairy product and sugar industry had lower technical efficiency than vegetable oil and products, at 0.63 and 0.93, respectively. Furthermore, the study suggested that the research and development intensity and infrastructure accelerate the performance (technical efficiency) of the Indian food processing industry. Technical efficiency in the manufacturing industry was studied by Noor (2014). They reported that micro-enterprises suffer from technical inefficiency, as the simple average of technical efficiency is only 56.2 per cent. This study also revealed that the research and development expenses, training costs, and investment in technological capabilities positively impact SMEs in Malaysia's manufacturing industry. The result is supported by Im and Cho (2021), who analyzed the technical efficiency of SMEs in South Korea's manufacturing and service industry. The results via output-oriented DEA showed that SMEs could have better technical efficiency, at 24.4 per cent for the manufacturing industry and 33.8 per cent for the service industry. At the same time, the author found that high-efficiency manufacturing groups showed higher efficiency when the sustainability technological innovation funds such as SME research and development funding support were raised externally than when internal resources were used for innovation activities. Charoenrat and Harvie (2017) disclosed that the overall technical efficiency was low, and they used the DEA method to investigate the technical efficiency of Thai manufacturing SMEs. The empirical results also indicate that firm size, firm age, skilled labour, location, type of manufacturing ownership, cooperatives, foreign investment, and exports are all essential firm-specific factors in the technical efficiency of Thai manufacturing SMEs.

This study extends the application of DEA to Malaysia's FPI by building on previous studies that applied DEA to other industries by examining efficiency disparities between SMEs and LSEs. While no prior studies have comprehensively analyzed technical efficiency in Malaysia's FPI, focusing on SMEs and LSEs, this study fills a critical gap in the literature. Additionally, past research has identified factors such as information technology, infrastructure, training costs, foreign investment, and research and development as influential to technical efficiency in various industries. However, the factors affecting these have yet to be extensively examined in the context of Malaysia's FPI. This study addresses this gap by examining the technical efficiency of both SMEs and LSEs in Malaysia's FPI. Given the high proportion of SMEs in this industry, these variables suggest an industry-specific approach to addressing inefficiency, providing locally relevant insights into efficiency dynamics that have yet to be explored in the literature.

METHODOLOGY

This study focuses on the SMEs and LSEs in Malaysia's FPI and incorporates two stages of investigation. Firstly, this study uses output-oriented DEA to determine the technical efficiency of the SMEs and LSEs of Malaysia's FPI as the manufacturing firm or industry is more sensible in producing maximum output at a given input quantity. Technical inefficiency then becomes the dependent variable in the following stage, and Tobit regression is used to analyze the determinants of technical inefficiency.

Secondary and yearly data on the SMEs and LSEs of Malaysia's FPI was primarily obtained from the Department of Statistics Malaysia, Malaysian Investment Development Authority (MIDA), World Bank, and International Financial Statistics (IFS) from 2000 to 2017. The panel data of the outputs (value added) and inputs (number of labour, fixed capital, and variable costs) from the five sub-sectors of SMEs and LSEs in the FPI determine technical efficiency, as shown in Table 1. Furthermore, Table 2 provides the data sources and definitions of variables utilized for investigating the factors affecting technical inefficiency.

The theories and results from the literature discussed in the previous section have supported the selection of variables in this study. Therefore, this study incorporates training costs, research and development, information technology, public infrastructure, foreign direct investment, world oil prices, and trade openness. Malaysia promotes staff training through initiatives like the Hu. Thus, training cost (TRAINING) is expected to reduce inefficiency in the FPI. Research and development (RD) drives technological advancement, product innovation, and improvements in existing products and production processes and is anticipated to reduce inefficiency. Information technology (IT) encourages manufacturers to adopt new technologies in production processes and operations in Malaysia, which is also expected to decrease inefficiency. Public infrastructure (GOVERNMENT) represents government expenditure on public facilities, which not only lowers production costs but may also reduce inefficiency in the FPI, possibly adversely affecting inefficiency. Foreign Direct Investment (FDI) brings substantial, long-term capital from abroad into the domestic economy. It is likely to enhance efficiency in Malaysia by funding production and management growth in the FPI, and it is anticipated to decline in inefficiency. World oil prices (ENERGY) are critical in manufacturing due to their influence on production and transportation costs. Thus, increases in oil prices could reduce the efficiency of the FPI and are expected to impact inefficiency positively. Trade openness (OPENNESS) facilitates the flow of international capital and goods and fosters growth in Malaysia's industry and economy. In this study, trade openness is expected to affect inefficiency negatively.

Table 1

Data Source and Definition for the Efficiency Analysis

Variables	Definitions	Data Sources
Output:		Department of Statistics Malaysia
VALUE ADDED	Total value added	
Input:		
LABOUR	Total number of persons engaged	
CAPITAL	Total value of fixed assets	
VARIABLE COST	Total cost of raw materials/ components/ parts used, water purchased, electricity purchased, and fuels used	

Table 2

Data Source and Definition for the Factor Affecting the Inefficiency Analysis

Variables	Definitions	Source
Dependent Variable:		
INEFF	One minus the VRS technical efficiency score	Calculation by using the DEA method
Independent variable:		
TRAINING	Total staff training cost	Department of Statistics Malaysia
RD	Total research and development expenditure	
IT	Payment for data processing and other services related to information technology	
GOVERNMENT	Government expenses for infrastructure	
FDI	Total foreign direct investment in the food processing industry	Malaysian Investment Development Authority (MIDA)
ENERGY	World oil prices	World Bank
OPENNESS	Trade openness index	International Financial Statistics (IFS)

Data Envelopment Analysis (DEA) Approach

According to Coelli et al. (2005), the output-oriented DEA model is represented through constant return to scale (CRS) and variable return to scale (VRS). Charnes et al. (1978) initially developed the Charnes, Cooper, and Rhodes (CCR) model, which serves as the fundamental framework for DEA. The DEA has been employed in this study as follows:

$max_{\theta,\lambda}\ \theta,$
Subject to
$-\theta VALUE\ ADDED_i + (VALUE\ ADDED_1\lambda + VALUE\ ADDED_2\lambda + VALUE\ ADDED_3 +$
$VALUE\ ADDED_4\lambda + VALUE\ ADDED_5\lambda) \geq 0,$
$CAPITAL_i - (CAPITAL_1\lambda + CAPITAL_2\lambda + CAPITAL_3\lambda + CAPITAL_4\lambda + CAPITAL_5\lambda) \geq 0,$
$LABOUR_i - (LABOUR_1\lambda + LABOUR_2\lambda + LABOUR_3\lambda + LABOUR_4\lambda + LABOUR_5\lambda) \geq 0,$
$VARIABLE\ COST_i - (VARIABLE\ COST_1\lambda + VARIABLE\ COST_2\lambda + VARIABLE\ COST_3\lambda +$
$VARIABLE\ COST_4\lambda + VARIABLE\ COST_5\lambda) \geq 0,$
$\lambda \geq 0,$ (1)

where $VALUE\ ADDED_i$ serves as the output of the five firms; $CAPITAL_i$, $LABOUR_i$, and $VARIABLE\ COST_i$ represent the inputs for five firms; λ is an $I \times 1$ vector of the constant; θ is a scalar that depicts the technical efficiency level of a firm; the technical efficiency measure is restricted; and the efficiency value is between 0 and 1. In other words, the inefficiency value equals one minus the efficiency score.

While the CRS assumption assumes all firms operate at an optimal scale, factors such as imperfect competition and government regulation may lead some firms to deviate from this optimal scale. Therefore, several authors have proposed modifying the CRS DEA model to accommodate situations with variable returns to scale (VRS) DEA model. The VRS DEA model used here is as follows:

$max_{\theta,\lambda}\ \theta,$
Subject to
$-\theta VALUE\ ADDED_i + (VALUE\ ADDED_1\lambda + VALUE\ ADDED_2\lambda + VALUE\ ADDED_3 +$
$VALUE\ ADDED_4\lambda + VALUE\ ADDED_5\lambda) \geq 0,$
$CAPITAL_i - (CAPITAL_1\lambda + CAPITAL_2\lambda + CAPITAL_3\lambda + CAPITAL_4\lambda + CAPITAL_5\lambda) \geq 0,$
$LABOUR_i - (LABOUR_1\lambda + LABOUR_2\lambda + LABOUR_3\lambda + LABOUR_4\lambda + LABOUR_5\lambda) \geq 0,$
$VARIABLE\ COST_i - (VARIABLE\ COST_1\lambda + VARIABLE\ COST_2\lambda + VARIABLE\ COST_3\lambda +$
$VARIABLE\ COST_4\lambda + VARIABLE\ COST_5\lambda) \geq 0,$
$I'_{I\times 1}\lambda = 1$
$\lambda \geq 0,$ (2)

where $I'_{I\times 1}\lambda = 1$ is the convexity constraint that guarantees that an inefficient firm is compared only to firms of comparable size, essentially creating a fair benchmarking process. VRS DEA tightens the data points more effectively than CRS, resulting in technical efficiency scores that are either greater than or equal to those obtained using the CRS model. Figure 4 shows the projected outcomes of the DEA analysis. This study first shows the four projected outcomes, the mean efficiency score of VRS and CRS for both LSEs and SMEs, followed by the annual efficiency score RS and CRS for both LSEs and SMEs, with 72 projected outcomes.

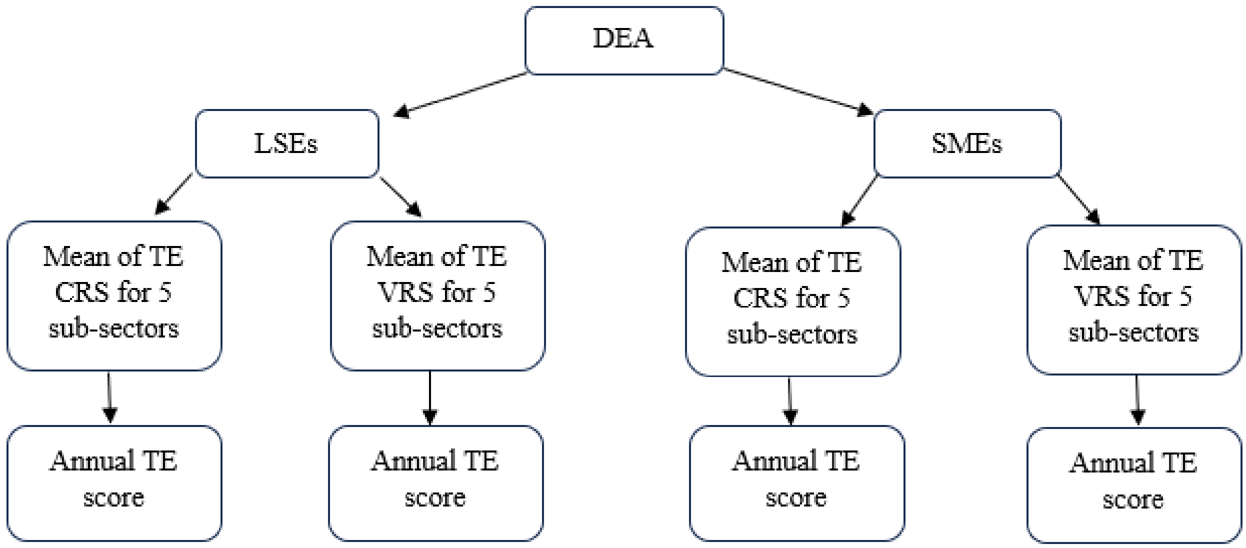
Tobit Regression

After obtaining the technical efficiency score from the previous estimation (DEA), Tobit regression was employed to investigate the factor affecting the technical inefficiency of VRS (Charoenrat & Harvie, 2017;

Im & Cho, 2021; Khan & Abdulla, 2019; Le et al., 2021; Shamsudin et al., 2011). VRS is considered in this study rather than CRS because CRS is suitable for assuming all the firms perform at an optimal scale. Still, the firms are not executing at an optimal scale in the real world, as the market does not offer perfect competition, government controls, and restrictions on financing (Coelli et al., 2005).

Figure 4

Projected Outcome of DEA Analysis



The technical efficiency score is between 0 and 1; hence, inefficiency is attained by one minus the efficiency score. Tobit regression is a pertinent model for determining the factor affecting technical inefficiency as the dependent variable is censored and truncated. In previous research (Bhandari & Valiyattoor, 2016; Charoenrat & Harvie, 2017; Kannan & Birthal, 2010; Khan & Abdulla, 2019; Maji et al., 2020; Mitra et al., 2015, 2016; Noor, 2014; Phan, 2004; Sabli et al., 2019; Shanmugam & Venkataramani, 2006), the dependent variable has been technical inefficiency (INEFF), while the independent variables included training cost (TRAINING), research and development (RD), information and technology (IT), foreign direct investment (FDI), public infrastructure (GOVERNMENT), world oil prices (ENERGY) and trade openness (OPENNESS).

The Tobit regression as follows:

$$\ln INEFFI_{it} = \beta_0 + \beta_1 lnTRAINING_{it} + \beta_2 lnRD_{it} + \beta_3 lnIT_{it} + \beta_4 lnFDI_{it} + \beta_5 lnGOVERNMENT_{it} + \beta_6 lnENERGY_{it} + \beta_7 lnOPENNESS_{it} + u_{it} \quad (3)$$

RESULTS

Technical Efficiency Score (DEA results)

Table 3 shows the technical efficiency (TE) of SMEs and LSEs in Malaysia's FPI. The average TE score for constant return to scale (CRS) is 0.94, which reflects that SMEs can enlarge the output by as much as 6 per cent. At the same time, the average score of TE in variable return to scale (VRS) is 0.99, indicating that SMEs produce an output of 0.99 for a given level of input used in production. Regarding LSEs, the TE score is 0.67 and 0.94 in CRS and VRS, respectively. The TE for CRS implies that the LSEs could enhance 32.7 per cent of the output by the same level of inputs, and the TE for VRS shows that the LSEs could increase the output level by around 6 per cent for the given number of inputs. Table 3 demonstrates that the value of CRS is lower than the value of VRS. This is because the CRS model has a tightened enveloping surface and assumes the industry is performing at the optimal scale. Furthermore, the measurement of VRS is weighed against a firm's non-linear possibility production function, as a firm may have a shorter distance to the possibility production function. In contrast, CRS is weighed against the linear possibility production function.

FPI showed a continuously diminishing production growth from 2010 to 2013 and negative production growth in 2013 (Figure 2); the TE of LSE also declined from 2010 to 2013. Additionally, Figure 2 implies the adverse production growth in 2011 and 2015, and the TE of SMEs also dropped in the same years. This result validates the problem of inefficiency in the FPI. In short, the findings of this study align with the problem statement, as the TE from DEA confirms that Malaysia's FPI suffers from inefficiency.

Descriptive Statistics

Table 4 shows the descriptive statistics of the dependent and independent variables utilized to examine the factors affecting the technical inefficiency of SMEs. The dependent variable is the VRS technical inefficiency score, obtained by one minus the TE score from DEA. VRS has been used in this study because it explains the reality as the return to scale is varied rather than constant. The seven independent variables are training cost, research and development, information and technology, foreign direct investment, expenses on public infrastructure, world oil prices, and trade openness. The mean of all independent variables is higher than their relative standard deviation, which means that all the independent variables are under-dispersed. Additionally, trade openness has the highest standard deviation among all the variables, indicating the most extensive variation in trade openness.

A summary of the descriptive statistics of LSEs in Malaysia's FPI for the period 2000 – 2017 is presented in Table 5. It illustrates that the average technical inefficiency is 0.06, while the mean training cost, research and development, and expenses on information technology are 4.02 per cent, 4.58 per cent and 4.06 per cent, respectively. Government expenditure on public infrastructure has an average of 7.94 per cent. The statistics also indicate that the mean of macroeconomic variables such as foreign direct investment, world oil prices, and trade openness are 5.91 per cent, 2.29 per cent, and 172.12 per cent, respectively. Furthermore, the means of explanatory and response variables are greater than their standard deviations. The data points tend to be close to the mean of the data set.

Table 3

Technical Efficiency Score

	SMEs		LSEs	
	Technical Efficiency		Technical Efficiency	
Year	CRS	VRS	CRS	VRS
2000	0.95	1.00	0.55	0.89
2001	0.91	1.00	0.51	0.89
2002	0.86	0.97	0.52	0.95
2003	0.93	0.97	0.53	0.93
2004	0.89	0.94	0.51	1.00
2005	0.96	0.97	0.53	0.92
2006	0.93	0.98	0.53	0.93
2007	0.94	0.98	0.56	0.93
2008	0.90	0.99	0.65	0.95
2009	0.98	0.98	0.65	0.95
2010	1.00	1.00	0.80	0.94
2011	1.00	1.00	0.79	0.94
2012	0.93	0.98	0.79	0.95
2013	0.96	1.00	0.79	0.91
2014	0.96	1.00	0.81	0.93
2015	0.97	1.00	0.83	0.96
2016	0.96	1.00	0.87	0.98
2017	0.91	1.00	0.89	1.00
Mean	**0.94**	**0.99**	**0.67**	**0.942**

Table 4

SMEs Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
INEFF	18	0.01	0.02	0.00	0.06
TRAINING	18	4.02	0.39	3.56	4.73
RD	18	4.58	0.60	3.66	5.71
IT	18	4.06	0.19	3.73	4.41
FDI	18	5.91	0.26	5.57	6.40
GOVERNMENT	18	7.94	0.21	7.56	8.22
ENERGY	18	2.29	0.20	1.94	2.53
OPENNESS	18	172.17	31.42	126.90	220.41

Table 5

LSEs Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
INEFF	18	0.06	0.03	0.00	0.11
TRAINING	18	4.19	0.39	3.64	5.09
RD	18	4.70	0.62	4.01	5.88
IT	18	4.35	0.50	3.59	5.41
FDI	18	5.91	0.26	5.57	6.40
GOVERNMENT	18	7.94	0.21	7.56	8.22
ENERGY	18	2.29	0.20	1.94	2.53
OPENNESS	18	172.17	31.42	126.90	220.41

Unit Root Test Results

Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests have been adopted in this study as they are carried out in a time series analysis to identify the non-stationary variables. Table 6 discloses the unit root test result on the level and first difference variables in SMEs' technical inefficiency analysis. ADF and PP stationary tests have revealed that all the variables are integrated in order one in level I (1).

Table 6

SMEs Unit Root Test Result

Variable	ADF		PP	
	At level	1st difference	At level	1st difference
INEFF	0.21	0.00***	0.20	0.00***
TRAINING	0.83	0.01***	0.84	0.01***
RD	0.72	0.00***	0.76	0.00***
IT	0.21	0.00***	0.22	0.00***
FDI	0.16	0.00***	0.19	0.00***
GOVERNMENT	0.24	0.04**	0.27	0.05**
ENERGY	0.25	0.03**	0.25	0.03**
OPENNESS	0.91	0.04**	0.90	0.04**

Note: ***, **, * denote statistical significance at 1 per cent, 5 per cent, and 10 per cent significant levels.

Table 7 shows the results of the unit root test on the dependent and independent variables of the LSEs' technical inefficiency investigation. All the variables except technical inefficiency are stationary at the first difference, which indicates that all the independent variables are an I(1) variable. Technical inefficiency does not contain a unit root at level, as it is an I(0) variable.

Tobit Regression Results

Table 8 summarizes the factors affecting SMEs' technical inefficiency in Malaysia's FPI. Staff training (TRAINING) has a statistically significant negative impact on technical inefficiency at the 1 per cent level, which means that staff training positively affects TE in SMEs. Investments in the education and training of workers improve the productivity and efficiency of the industry. This result is consistent with that of previous studies (Noor, 2014). This paper suggests that the positive coefficient of information and technology (IT) is statistically significant, as technical inefficiency increases in the information and technology expenses reduce the TE, supported by Khan and Abdulla (2019), Mitra et al. (2016) and Sabli et al. (2019).

Table 7
LSEs Unit Root Test Result

Variable	ADF		PP	
	At level	1^{st} difference	At level	1^{st} difference
INEFF	0.05**	0.00***	0.06*	0.00***
TRAINING	0.19	0.00***	0.23	0.00***
RD	0.96	0.00***	0.98	0.00***
IT	0.95	0.00***	0.97	0.00***
FDI	0.16	0.00***	0.19	0.00***
GOVERNMENT	0.24	0.04**	0.27	0.05**
ENERGY	0.25	0.04**	0.25	0.03**
OPENNESS	0.91	0.04**	0.90	0.04**

Note: ***, **, * denote statistical significance at 1 per cent, 5 per cent, and 10 per cent significant levels.

This finding reflects that the SMEs of Malaysia's FPI might be labour-driven or labour-intensive, as using information and technology or capital intensive does not improve the SMEs in the FPI. Government infrastructure expenditure (GOVERNMENT) is suspected to positively affect technical inefficiency, which means that public infrastructure development worsens TE. This might be due to the public infrastructure investing in the development of the city or property rather than the development of the SME industry. In addition, public facility maintenance or construction might intervene in business operations, increasing the cost of SMEs. This result aligns with that of previous work (Shanmugam & Venkataramani, 2006).

Trade openness (OPENNESS) captures the effects of international trade; high trade openness increases market share and competitiveness of the industry. This study explains that trade openness positively and significantly relates to technical inefficiency. In other words, trade openness mitigates TE at a 1 per cent significant level. Trade openness represents the removal of trade barriers and harms local enterprises, especially SMEs, as SMEs do not fulfil international competency requirements, and local consumers prefer higher-quality foreign products. This leads to local enterprises becoming more competitive than overseas enterprises. SMEs may find it hard to encounter foreign competition. A company must be strongly competitive to compete and succeed globally (Maji et al., 2020).

This study also finds that research and development (RD) significantly negatively influences technical inefficiency. This suggests that research and development directly affect TE, promoting innovation and improvement in the production process. This finding is identical to that of other studies (Bhandari & Valiyattoor, 2016; Noor, 2014; Sabli et al., 2019). According to the present study, foreign direct investment (FDI) is negatively related to technical inefficiency or positively connected to TE, with a 5 per cent significant level in the SMEs of the FPI. An increase in foreign funding facilitates the SMEs of the FPI to accelerate management, production, and efficiency. This finding has also been revealed in previous studies by Charoenrat and Harvie (2017) and Phan (2004). Furthermore, the world oil price (ENERGY) has an inverse relationship with technical inefficiency, but this effect is insignificant. This provides insight into the fact that high-low world oil prices do not significantly impact the TE of SMEs.

Table 8

SMEs Tobit Regression

INEFF	Coefficient
TRAINING	-0.11***
RD	-0.03**
IT	0.16***
FDI	-0.08**
GOVERNMENT	0.53***
ENERGY	-0.06
OPENNESS	0.00***

Note: ***, **, * denote statistical significance at 1 per cent, 5 per cent, and 10 per cent significant levels.

The findings of the factors affecting LSEs' technical inefficiency are presented in Table 9. Surprisingly, this study provides a statistically significantly positive connection between research and development (RD) and technical inefficiency. This indicates that the high-level funding in research and development is hampering the TE of LSEs, and this may be due to the LSEs investing in operational development rather than production, such as installing 4G LTE technology and advancing the equipment in the working environment. This divergent result is revealed in existing papers (Barasa et al., 2015; Gumbau-Albert & Maudos, 2002); it could be due to the research and development has a dynamic effect on TE, as the current investment in research and development might bring about the TE in future (Gumbau-Albert & Maudos, 2002). It might also be because a company encourages research and development to enhance the TE within the company. At the same time, it brings about inefficiency in the companies that do not employ research and development. This causes inefficiency in the industry as a whole (Barasa et al., 2015).

Government expenditures on infrastructure (GOVERNMENT) have a negative and significant effect on technical inefficiency, and they significantly positively affect the TE of LSEs. The estimation result shows that government investment in public infrastructure is beneficial to LSEs. For example, the government may set up the industrial park while facilitating the LSEs by creating a convenient transport network, lowering the cost of operation, and providing a highly attractive location. This result is similar to the studies (Bhandari & Valiyattoor, 2016; Mitra et al., 2015, 2016).

Table 9 shows that world oil prices (ENERGY) and technical inefficiency have a significant and positive relationship, which means that the world oil price is decreasing TE. This might be due to an increase in world oil prices, which increases transportation costs and reduces the revenue of LSEs. On the other hand, trade openness (OPENNESS) mitigates technical inefficiency with a 10 per cent significant level, which indicates that the loosened trade barrier boosts the TE of LSEs. This might be because LSEs can increase market penetration in foreign countries and purchase raw materials from overseas at a lower cost. This result is in line with previous research (Kannan & Birthal, 2010; Maji et al., 2020; Phan, 2004).

Training cost (TRAINING) and information technology (IT) negatively affect the technical inefficiency of LSEs in Malaysia's FPI. This indicates that LSEs invest more in staff training and information technology for higher TE. Training improves the quality and performance of the workers and leads to TE, as information technology is an important component in modernizing the business operation. However, these coefficients are not provided significantly, implying that the training cost and information technology do not have strong evidence to show that these variables affect the LSEs. In this study, foreign direct investment (FDI) also does not suggest a significant coefficient. This indicates that foreign funding has no statistical impact on the LSEs' TE.

Table 9

LSEs Tobit Regression

INEFF	Coefficient
TRAINING	-0.00
RD	0.07*
IT	-0.04
FDI	0.04
GOVERNMENT	-0.67***
ENERGY	0.26***
OPENNESS	-0.00*

Note: ***, **, * denote statistical significance at 1 per cent, 5 per cent, and 10 per cent significant levels.

CONCLUSION

Malaysia's FPI might encounter inefficiencies due to uncertain production growth. Hence, this study examines the TE level of SMEs and LSEs in Malaysia's FPI and evaluates the factors affecting technical inefficiency. The findings show that SMEs' average TE scores in Malaysia's FPI are high, at 0.94 for CRS and 0.99 for VRS. SMEs could increase output by up to 6 percent (CRS) and 1.4 percent (VRS) at the same input level. The average TE value in LSEs is much lower than SMEs, at 0.67 and 0.94 for CRS and VRS, respectively. The empirical result reflects that the LSEs and SMEs do not operate efficiently, meaning that these companies could improve output by managing resources more effectively to ensure efficiency in producing the maximum output and increasing production growth.

Key determinants affecting efficiency differ between SMEs and LSEs, reflecting their unique operational structures and competitive environments. For SMEs, training costs, research and development, and foreign direct investment positively influence efficiency, while information technology, public infrastructure, and trade openness have a negative effect. Conversely, LSE efficiency benefits from public infrastructure and trade openness while being negatively impacted by research and development and world oil prices.

In Malaysia, SMEs have been recognized as important contributors to economic development, especially the FPI. Local enterprises, particularly SMEs, are vital, especially during a crisis. For instance, they support the needs of the market rather than foreign corporations during the Covid-19. If foreign companies outcompete local enterprises, overseas companies will necessarily dominate the local market and economy. Therefore, it is necessary to create a policy that protects local companies and controls the openness of foreign enterprises. The policy implications of these findings are significant. Firstly, to improve SMEs' efficiency, policies should focus on investment in technological resources, research and development subsidies, and government-supported training. The government could provide incentives such as tax breaks on technology investments, research and development expenses, and partnerships for skill development.

This may help SMEs overcome resource and skill limitations and enhance their competitiveness in the local and international markets. Policies for LSEs could focus on stabilizing infrastructure investment and creating incentives that leverage trade openness while managing the impacts of volatile oil prices on production costs. This study provides valuable insights into the efficiency levels within Malaysia's FPI, distinguishing the unique efficiency drivers and constraints SMEs and LSEs face. By providing an evidence-based framework, policymakers are equipped with targeted strategies to address these unique challenges. This study also supports efforts to enhance competitiveness and promote sustainable growth throughout Malaysia's FPI through these focused policy measures.

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